REMARKS

Claims 1-17 are pending.

Claims 1-17 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 63,13,392 to Sato et al. ("Sato) in view of Pre-Grant Publication No. 2002/00268856 to Suzuki et al. ("Suzuki").

Applicants traverse.

The Office Action asserts that Sato teaches a thermoelectric material and method of preparation including a thermoelectric material made up of spherical powders of minute size with densities of at least 85% with the required resistivities, compositions and other physical properties that are recited in the instant claims where the material is formed with pressing and annealing within the instantly recited ranges. The Office Action admits that Sato fails to teach the use of a material with a crystal having a particle size of at most 50 nm. The Office Action relies on Suzuki in an attempt to cure the deficiencies of Sato.

The Office Action asserts that Suzuki teaches that in the manufacture of thermoelectric materials it was known in the art at the time the invention was made to employ materials with average particle sizes below 50 nm in order to advantageously reduce the mean free path and to lower thermal conductivity. The Examiner contends that in order to advantageously lower the thermal conductivity of the material, it would have been obvious to one of ordinary skill in the art at the time the invention was made to employ average crystal grain sizes of no more than 50 nm, as taught by Suzuki for the crystals produced in the thermoelectric material of Sato.

Turning to the cited references, Suzuki discusses depositing powders on a substrate by the ***laser ablation method***. On the other hand, Sato discusses ***sintering*** the powders.

It is well known by persons skilled in the art that sintering requires an increase in pressure and that the increase of the sintering pressure results in an increase in the density of a sintered body and the simultaneous growth of crystal grains. When nano powders are obtained by the laser ablation method by sintering the powder under high pressure, the formed sintered body of crystal grains cannot obtain a size on the order of nanometers due to the growth of crystal grains. The powders of Suzuki and Sato are considerably different from the claimed thermoelectric material in structure.

According to an aspect of the present application, when powders are sintered under the high pressure of 1 GPa or more, the growth of crystal grains is restrained resulting in a thermoelectric material having an average crystal particle size of at most 50 nm and a relative density of at least 85% (*see, e.g.*, pg. 9, lines 20-29).

The following Table A shows the relation between the sintering pressure and the thermoelectric material's properties (the average crystal particle size and the relative density). The data shown in Table A is extracted from Table 3 and Table 4 of the instant specification.

Table A: the relation of the sintering pressure and the thermoelectric material's properties

No. (corresponding to the specification)	Sintering pressure (GPa)	Sintering temperature (°C)	Average particle size of sintered body (μm)	Relative density (%)
20 (Comparative Example)	0.1	1400	5	82
21 (Comparative Example)	0.8	1300	1.5	84
8 (Example)	1	900	0.05	89
9 (Example)	3	900	0.035	93
10 (Example)	5	820	0.023	96

In Examples 8-10 and Comparative Examples 20-21, powders having average crystal particle size of 5-10 nm are used as a raw material. However, in Comparative Examples 20-21, the crystal grains grow in the powders, and the average particle size is 1.5 or 5 μm, respectively.

On the other hand, in the instant case, as illustrated in Examples 8-10, the relative density increases while the growth of crystal grains is controlled to form sintered bodies having an average crystal particle size of at most 50 nm and the relative density of at least 85 %, as required by claim 1. Thus, Table A and the corresponding specification show that the growth of crystal grains is restrained, as the sintering pressure increases in the present application.

Suzuki and Sato are *silent* regarding the claimed thermoelectric material having an average crystal particle size of at most 50 nm **and** relative density of at least 85%. Further, Suzuki is *silent* regarding a crystal particle size of at most 50 nm, so there is no basis for alleging obviousness thereof. Therefore, the cited prior art does not recognize the advantage of an average crystal particle size of at most 50 nm and the relative density of at least 85 %, as required by claim 1. The present inventors, however, have discovered that the decrease in the average crystal particle size is an effect of increased sintering pressure (*see,* pg. 9, lines 20-29 and Tables 3 & 4). This unexpected result is not suggested by the cited references.

Neither Suzuki nor Sato, individually or combined, disclose or infer, "...a thermoelectric material having an average crystal particle size of at most 50 nm and having a relative density of at least 85 %," as recited in claim 1.

Further, the present inventors studied the amount of the impurities at the boundaries of the crystal grains and their properties, and found that the amount of the impurities at the boundaries of the crystal grains affected the properties of the thermoelectric material. As

discussed in the instant specification, impurities are contaminated from the outside and generated by oxidizing the surfaces of the grains. These impurities also exist uniformly inside and outside the grains. Since the claimed thermoelectric material has a crystal grain size on the order of nanometers and are manufactured by sintering the powders under higher pressure compared to the conventional pressure, the increased impurities are predominantly found at the boundaries of the crystal grains. Therefore, an aspect of the present application is to restrain the amount of the impurities existing at the boundaries of the crystal grains. This is not suggested by the cited references.

Comparing No. 7 of Table 2 of the instant specification with No. 5, by decreasing the amount of the impurities, such as oxygen, from 0.25 to 0.15 of the O-peak intensity measured by EDS, the electrical resistivity is decreased by 40 % and the performance of the thermoelectric material is increased by 70% (*see, e.g.,* pg. 13, lines 5-17). Thereby, as taught in the instant specification, reducing the amount of the impurities at the boundaries of the crystal grains of the thermoelectric material, reduces the electrical resistivity to improve the properties of the thermoelectric material.

With respect to claim 6, a method of manufacturing the thermoelectric material includes preparing a fine powder having an average particle size of at most 50 nm and sintering or compacting the fine powder under a pressure of at least 1.0 GPa and at most 10 GPa. Thereby, as taught in the instant specification, the electrical resistivity and the thermal conductivity is reduced by applying a pressure 10 times higher than the conventional sintering pressure (*see, e.g.* Tables 3 & 4 and the corresponding description, specifically a comparison between No. 10 of Table 3 with No. 23 of Table 4 of the instant specification). This unexpected result is not suggested by the cited references.

Accordingly, the rejection of claims 1-17 predicated on the combination of Suzuki and Sato should be withdrawn.

In view of the above remarks, Applicants submit that this application should be allowed and the case passed to issue. If there are any questions regarding this Response or the application in general, a telephone call to the undersigned would be appreciated to expedite the prosecution of the application.

To the extent necessary, a petition for an extension of time under 37 C.F.R. 1.136 is hereby made. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 500417 and please credit any excess fees to such deposit account.

Respectfully submitted,

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